Physics 311

Homework Set 12

1. Two concentric metal spherical shells, or radius a and b, respectively, are separated by weakly conducting material of conductivity σ (Fig. 7.4a).
   a) If they are maintained at a potential difference V, what current flows from one to the other?
   b) What is the resistance between the shells?

2. A metal bar of mass m slides frictionlessly on two parallel conducting rails a distance l apart (Fig. 7.16). A resistor R is connected across the rails and a uniform magnetic field $\vec{B}$, pointing *out of* the page, fills the entire region.
   a) If the bar moves to the right at speed v, what is the current in the resistor? In what direction does it flow?
   b) What is the magnetic force on the bar? In what direction?
   c) If the bar starts out with speed v_0 at time $t = 0$, and is left to slide, what is its speed at a later time t?

3. A square loop of wire (side a) lies on a table, a distance s from a very long straight wire, which carries a current I, as shown in Fig. 7.17.
   a) Find the flux of $\vec{B}$ through the loop.
   b) If someone now pulls the loop directly away from the wire, at speed v, what emf is generated? In what direction (clockwise or counterclockwise) does the current flow?

4. A square loop (side a) is mounted on a vertical shaft and rotated at angular velocity ω (Fig. 7.18). A uniform magnetic field $\vec{B}$ points right. Find $\mathcal{E}(t)$ for this alternating current generator.

5. A long solenoid, of radius a, is driven by an alternating current, so that the field is sinusoidal

$$\vec{B}(t) = B_0 \sin(\omega t)\hat{z}. \tag{1}$$

A circular loop of wire, of radius $3a/4$ and resistance R, is placed inside the solenoid, and coaxial with it. Find the current induced in then loop, as a function of time.

6. A square loop of wire, with sides of length a, lies in the first quadrant of the xy plane, with one corner at the origin. In this region there is a nonuniform time-dependent magnetic field

$$\vec{B}(y,t) = ky^2t^3\hat{z} \tag{2}$$

where k is a constant. Find the emf induced in the loop.

7. An alternating current $I(t) = I_0 \sin(\omega t)$ flows down a long straight wire, and returns along a coaxial conducting tube of radius b.
   a) In what direction does the induced electric field point (radial, circumferential, or longitudinal)?
   b) Assuming that the field goes to zero as $s \to \infty$, find $\vec{E}(s,t)$.